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RESEARCH MEMORANDUM

FLIGHT INVESTIGATIONS AT LOW SUPERSONIC SPEEDS TO DETERMINE THE EFFECTIVENESS OF CONES AND A WEDGE IN REDUCING THE DRAG OF ROUND-NOSE BODIES AND AIRFOILS

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NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

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FLIGHT INVESTIGATIONS AT LOW SUPERSONIC SPEEDS TO DETERMINE THE EFFECTIVENESS OF CONES AND A WEDGE IN REDUCING THE DRAG OF ROUND-NOSE BODIES AND AIRFOILS

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SUMMARY

Flight investigations covering an approximate Mach number range from 0.9 to 1.4 have been conducted to determine the effect of cones and a wedge in reducing the drag of round-nose bodies and airfoils. At $M = 1.4$ a 3-inch-long cone of 16° semivertex angle mounted about 8 inches ahead of a 5-inch-diameter round-nose body reduced the drag coefficient of that body by about 0.17 (21 percent) as compared to a reduction of about 0.21 (25 percent) obtained with a model having a pointed solid nose of effectively equal fineness ratio. The presence of a small leading-edge wedge mounted ahead of an unswept, round-nose airfoil did not appreciably affect the drag of the basic airfoil.

INTRODUCTION

Physical considerations indicate that if a small cone, herein sometimes termed a "conical windshield," is placed ahead of a blunt-nose body traveling at supersonic speeds, the low-velocity wake behind the windshield will expand and thus cause the external flow to follow the contour formed by the extension of the surface of the conical windshield. Thus, a small cone may produce substantially the same effect as a long pointed nose but have the advantages of improved visibility and reduced structural weight.

The effect of the length of a windshield having a cone semivertex angle of $11^{\circ}\ 10'$ in reducing the drag of a basic round-nose body has been presented in reference 1. The effect of increasing the semivertex angle of a 3-inch windshield to 16° is given in the present paper. These results are compared with those of reference 1.

[redacted]

This method, as applied to bodies, was considered promising enough to warrant an exploratory application to airfoils. A 5-percent-chord wedge having a semivertex angle of 5° 22' was placed 20 percent of the airfoil chord ahead of the wing of the test body of reference 2. This body incorporated an untapered, unswept NACA 65-009 airfoil of aspect ratio $A = 2.7$. The sides of the wedge, if extended, would become tangent to the airfoil surface. It was realized that for the anticipated flight Mach number range the shock wave would never become attached and the considerations previously mentioned would not strictly apply. This configuration was tested and the results compared with those of reference 2.

The investigation was conducted by the Langley Pilotless Aircraft Research Division at its testing station at Wallops Island, Va. Data have been obtained through an approximate Mach number range of 0.9 to 1.4. The corresponding Reynolds number range based on over-all body length is from 30×10^6 to 40×10^6.

MODELS AND TESTS

The basic model construction and configuration have been adequately described in references 1 and 2. The general arrangement of the test body incorporating the windshield is shown as figure 1. Details of the conical windshield are shown as figure 2. The winged test body with the leading-edge wedge is presented as figure 3. A discussion of the general testing technique and the accuracy of the resultant data is given in reference 1.

RESULTS AND DISCUSSION

The test results obtained for two similar windshield models are presented in figure 4 as plots of drag coefficient, based on body frontal area exclusive of fins, against Mach number. A comparison is made in figure 5 between these results and the results of previous drag tests of body-windshield combinations presented in references 1 and 3. Examination of this figure reveals that for the highest comparable Mach number reached during the tests, $M = 1.4$, the 3-inch-long windshield of the present tests (semivertex angle of 16°) reduced the drag coefficient of the basic round-nose body by about 0.17 (21 percent) as compared to a reduction of about 0.12 (14.5 percent) for the 3-inch-long windshield having a semivertex angle of 11° 10' and about 0.21 (25 percent) obtained with the standard body shown in figure 6.

This general condition exists over most of the Mach number range investigated. It is thereby clearly indicated that a conical windshield of relatively small dimensions can effectively increase the fineness ratio of a round-nose body at low supersonic speeds to the extent of producing substantially the same effect as a long pointed nose with the added advantages of improved visibility and reduced structural weight.

The test results obtained from firings of four similar models incorporating the leading-edge wedge are presented in figure 7. The values of drag coefficient are based on the exposed area of the basic airfoil (1.389 sq ft). The average scatter from the faired curve is within the general accuracy of the testing technique. By subtracting from the total drag of the model, the drag of the wingless arrangement shown in figure 6, the drag of the wing alone (plus interference) is obtained. This result is presented in coefficient form in figure 8 and is compared with the drag of the basic airfoil of reference 2. Examination of the figure reveals that in the range of comparable Mach numbers ($M = 1.05$ to 1.225) the presence of the wedge caused no appreciable difference in the drag of the basic airfoil, the difference in drag coefficient generally being within the accuracy of the tests. It should be realized that the tested arrangement may be by no means an optimum one and the results should be considered of preliminary nature.

CONCLUDING REMARKS

At $M = 1.4$, increasing the semivertex angle of a 3-inch-long conical windshield from $11^\circ 10'$ to 16° reduced the drag of a basic round-nose body from 14.5 percent to 21 percent. This condition existed over the general Mach number range investigated. It is clearly indicated from results of tests conducted at low supersonic speeds that a small cone placed ahead of a round-nose body can effectively reduce the drag of the basic body. The presence of a small wedge placed ahead of a round-nose airfoil did not appreciably affect the drag of the basic airfoil in the investigated Mach number range of 1.05 to 1.225.

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REFERENCES

1. Alexander, Sidney R., and Katz, Ellis: Flight Tests to Determine the Effect of Length of a Conical Windshield on the Drag of a Bluff Body at Supersonic Speeds. NACA RM No. L6J16a, 1947.

2. Alexander, Sidney R., and Katz, Ellis: Drag Characteristics of Rectangular and Swept-Back NACA 65-009 Airfoils Having Aspect Ratios of 1.5 and 2.7 as Determined by Flight Tests at Supersonic Speeds. NACA RM No. L6J16, 1946.

3. Alexander, Sidney R.: Effect of Strut-Mounted Wing Tanks on the Drag of NACA RM-2 Test Vehicles in Flight at Transonic Speeds. NACA RM No. L8H31a, 1948.

[redacted]

Figure 1.– General view of test body with 3-inch-long conical windshield of 16° [redacted] vertex angle.

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[redacted]

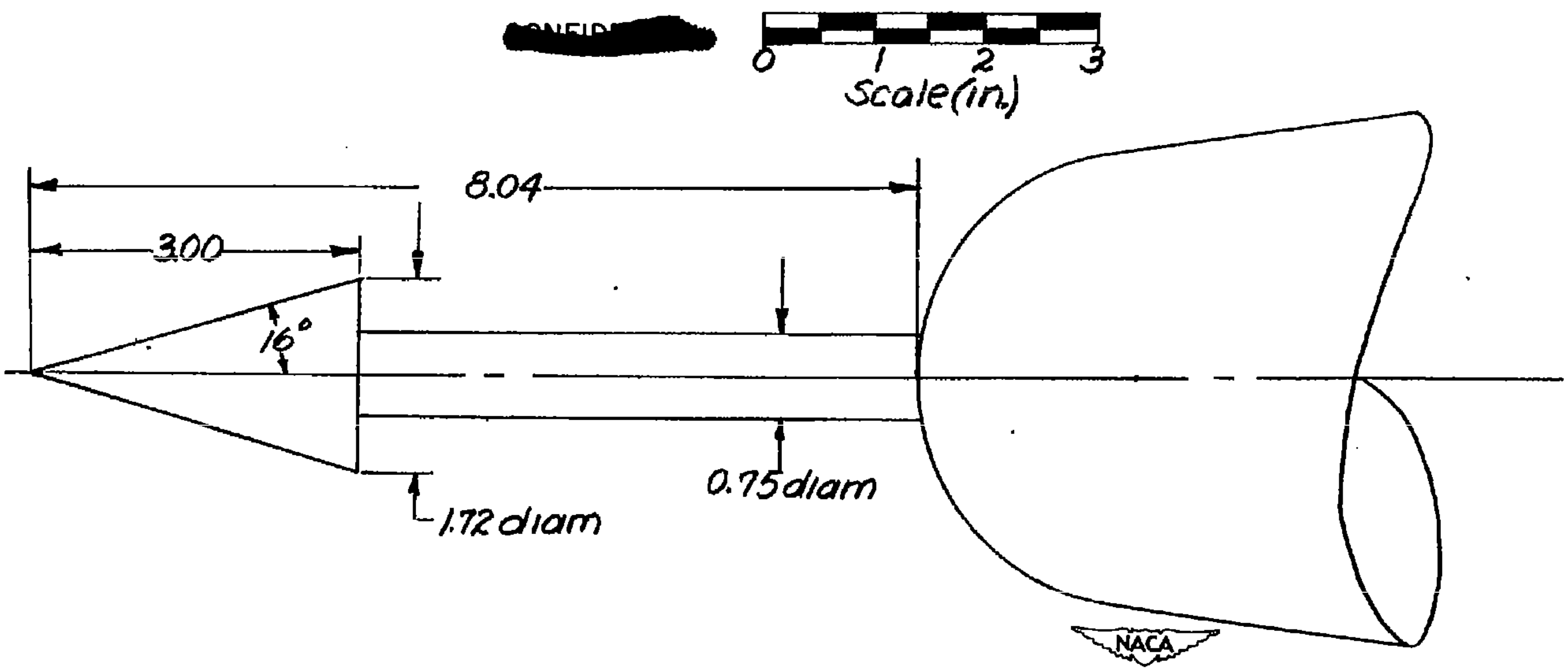

Figure 2.– General dimensions of conical windshield investigated.

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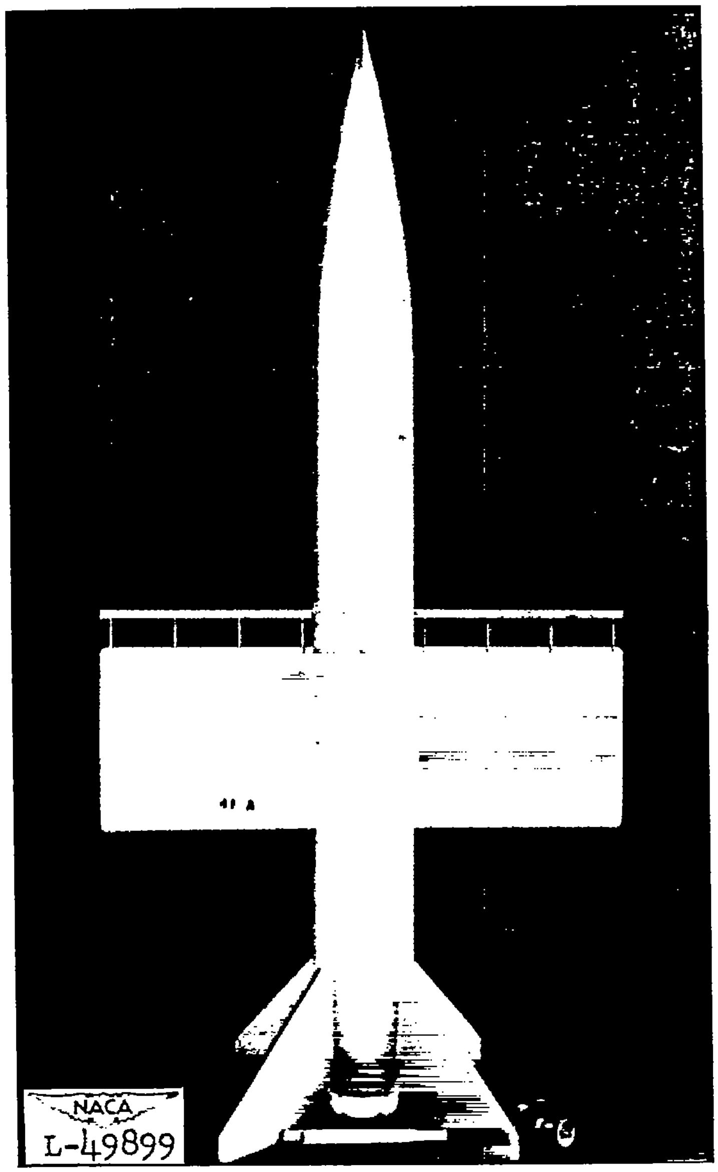

Figure 3.– General view of test body with leading–edge wedge.

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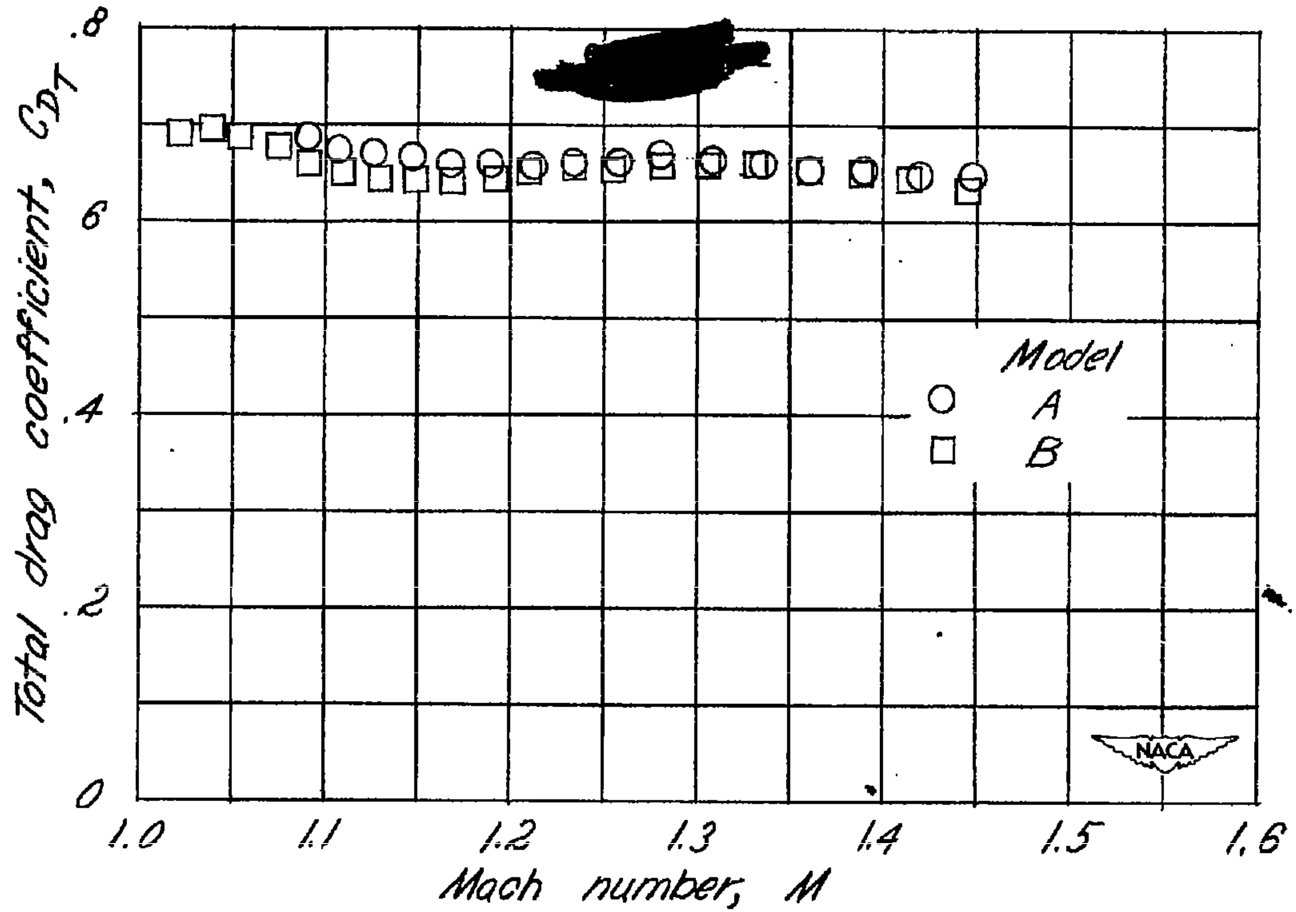

Figure 4.– Basic data for two models o[redacted]configuration: Test body with 3-inch-long conical windshield o[redacted]semivertex angle.

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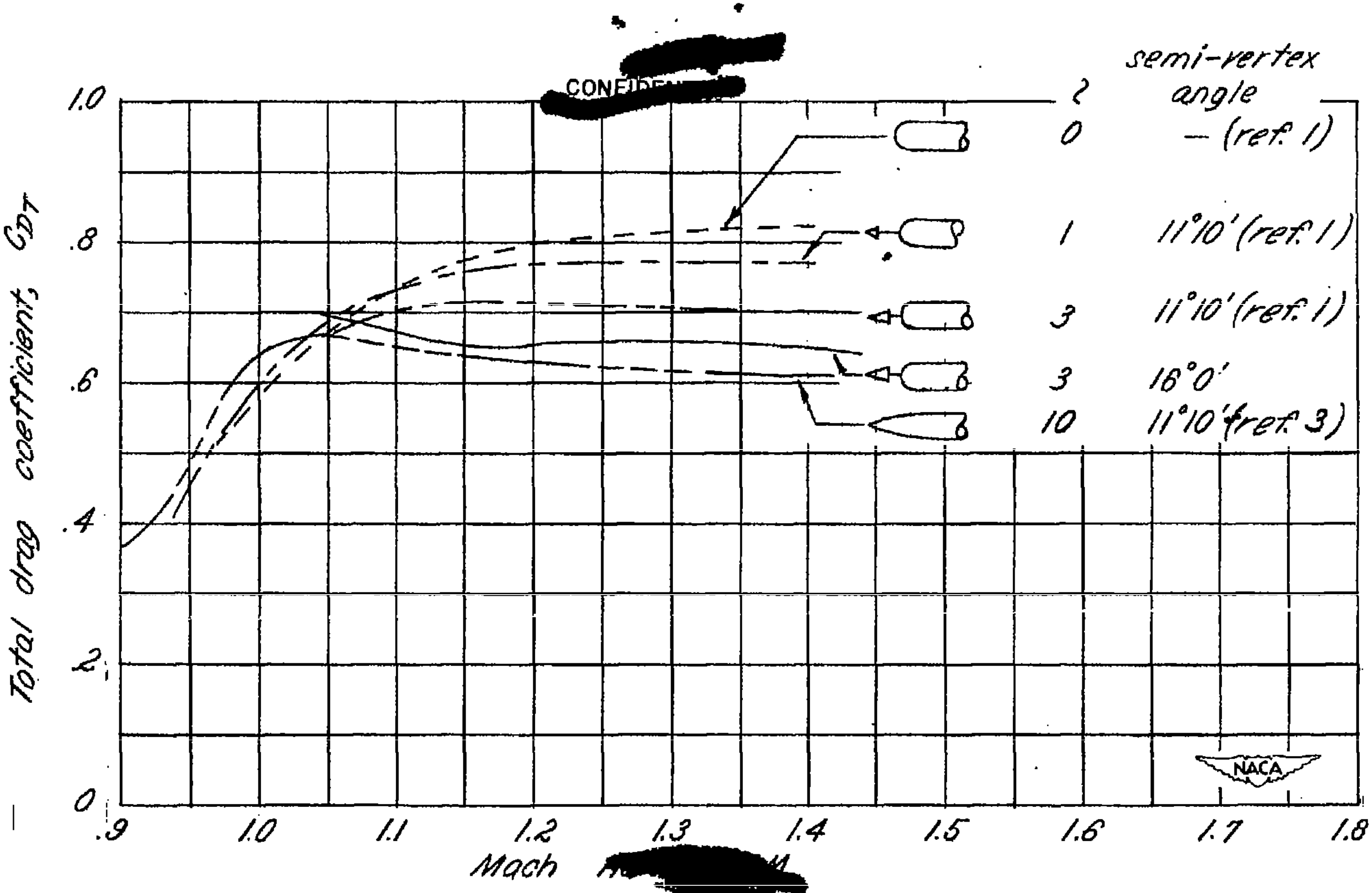

Figure 5.– Comparison of the effectiveness of several sizes of conical windshields in reducing the drag of a round-nose body. l windshield length.

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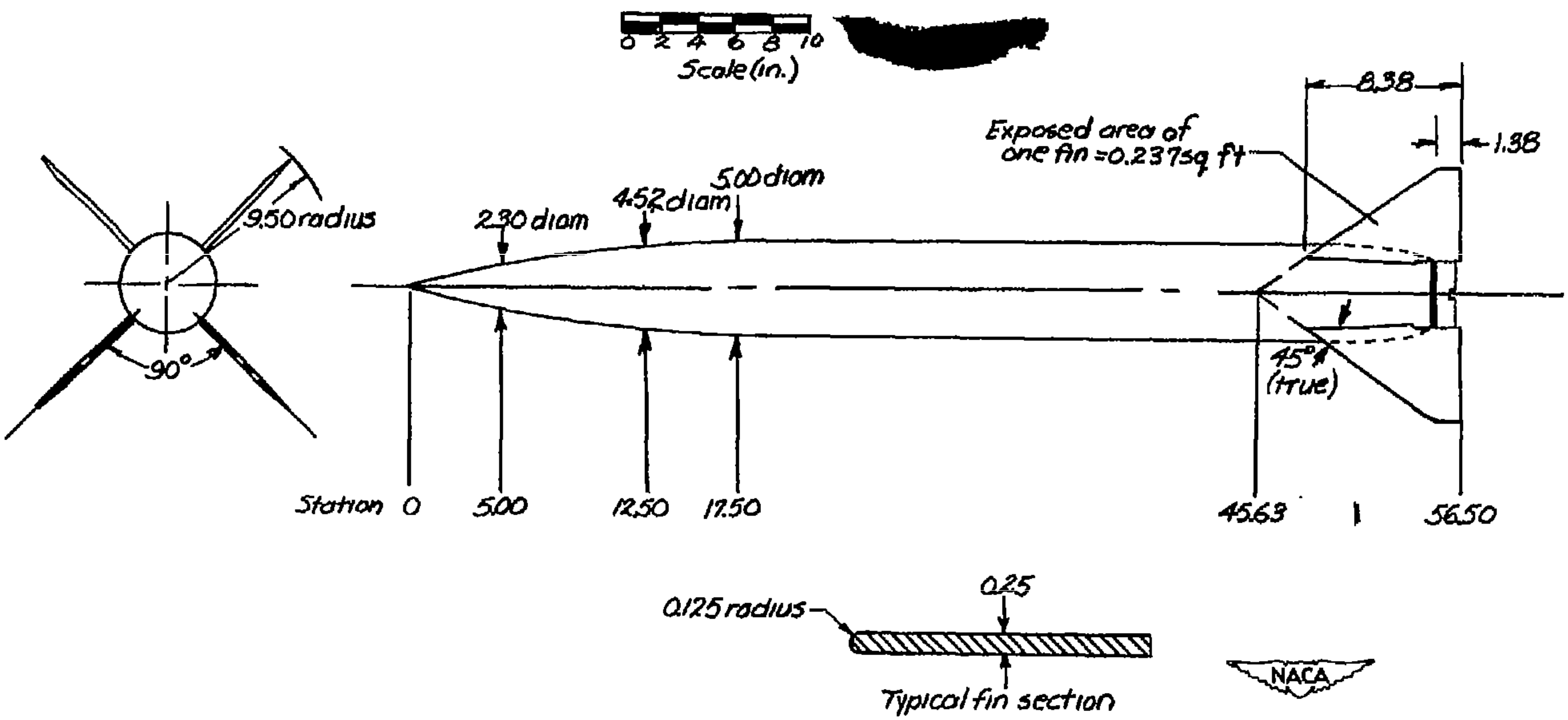

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Figure 6.– General arrangement of test body.

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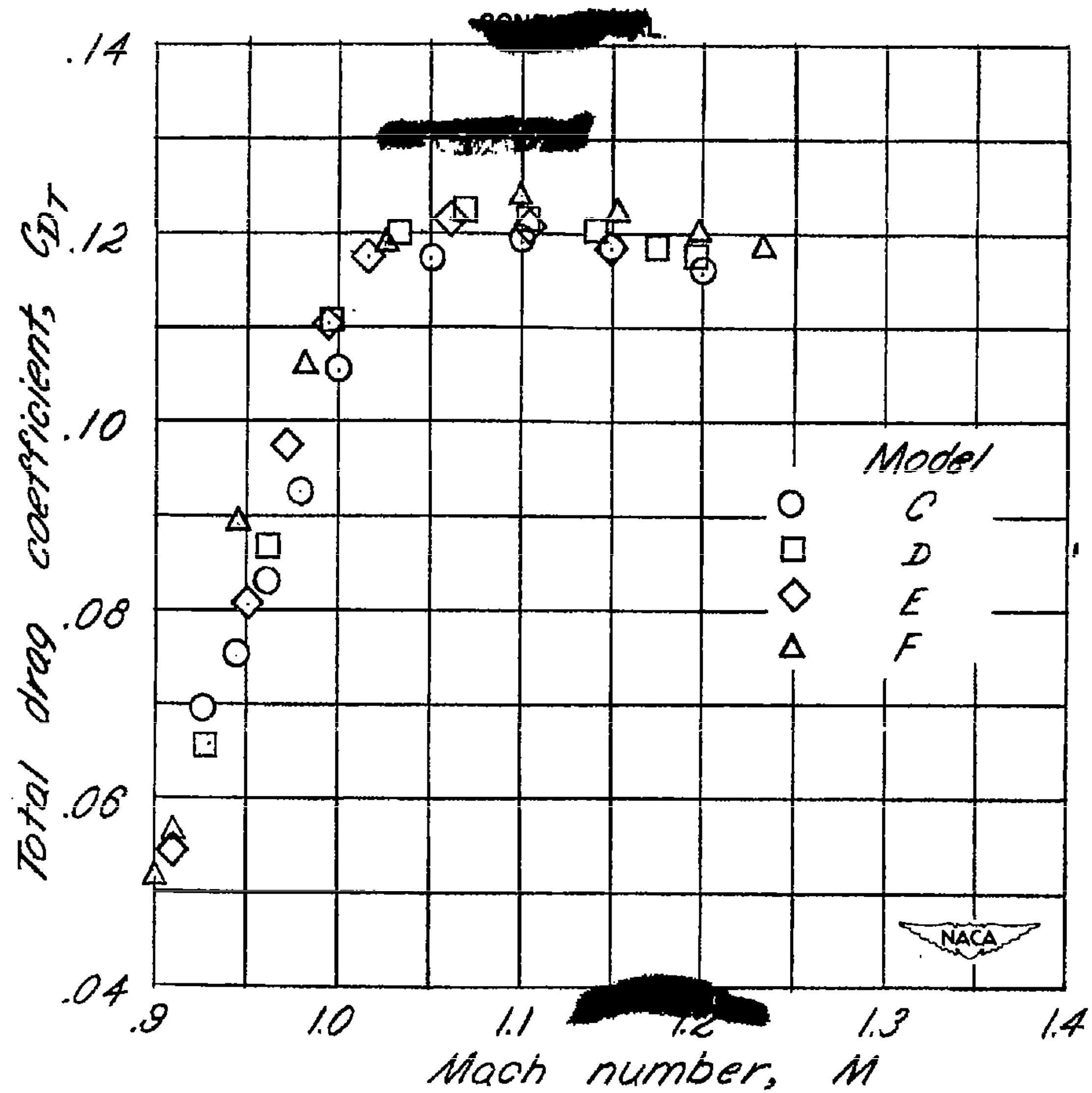

Figure 7. Basic data for four models of the same configuration: Wing with leading-edge wedge. $A = 2.7$; $\Lambda = 0^{\circ}$.

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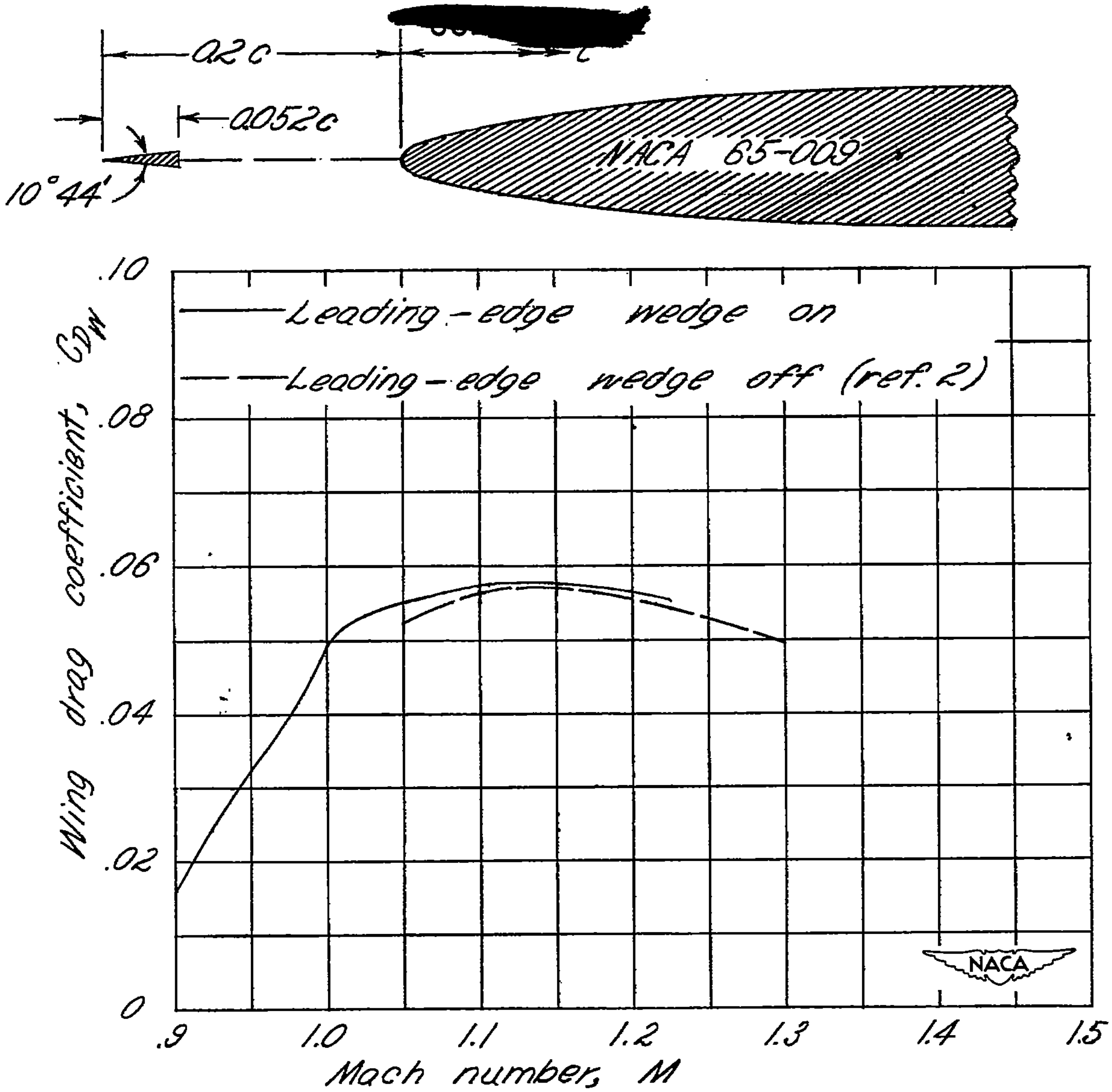

Figure 8.– Wing drag coefficients; leading-edge wedge on and off. $A = 2.7$; $\Lambda = 0^{\circ}$.

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